

Title: You use! I use! We use! - Questioning the orthodoxy of 1:1 computing in Primary Schools.

Word Count: 6 700 words

Contributor's Names and Contact Details:

Larkin, Kevin; University of Southern Queensland, Faculty of Education

- Email: Kevin.Larkin@usq.edu.au

Dr Kevin Larkin is a Lecturer in Information and Communication Technology (ICT)

Mathematics Education and Technology Education at the University of Southern Queensland.

He teaches Foundations of Numeracy and ICT and Pedagogy and Technology and Pedagogy and his research interests include mLearning, eLearning, ICT in Education, Activity Theory, and 1:1 Computing. He has published in the areas of mLearning, Activity Theory, Web 2.0 (under review) and Digital Citizenship.

Correspondence regarding this article should be addressed to

Kevin Larkin, Faculty of Education, Springfield Campus, University of Southern Queensland. PO Box 4196, Springfield Central, Queensland, Australia, 4300.

Email Kevin.Larkin@usq.edu.au

Title:**You use! I use! We use! - Questioning the orthodoxy of 1:1 computing in Primary Schools****Abstract:**

The current orthodoxy regarding computer use in schools appears to be that 1:1 computing, i.e. each child owns or has sole access to a computing device, is the most efficacious way to achieve a range of desirable educational outcomes including individualised learning, collaborative environments or constructivist pedagogies. This article challenges this notion suggesting instead that 1:2 computing is an appropriate means of achieving such aims in Primary School. It further suggests that 1:2 computing is preferable to 1:1 computing to achieve a balance between productivity, student engagement, social activity and individualised learning.

This article draws on data collected during the 2009 school year from four, Year 7 Classrooms (11-13 year old students) who had varied patterns of access to netbook computers. Detailed information was collected from two pieces of software installed in each computer. Data were analysed through an Activity Theory conceptual and methodological lens. Recommendations from this research will assist school leaders make informed decisions regarding 1:1 and 1:2 computing.

Keywords:

Computing, Primary education, Qualitative research, Activity Theory, 1:1 computing.

This article argues that it should not be presumed that 1:1 computing is the only appropriate means of providing substantial computing access to primary school students. It suggests that 1:2 computing is particularly beneficial in regards to student learning, classroom collaboration, and pedagogic approach, as well as offering considerable economic benefits in terms of school expenditure on ICT resources. This article draws on data collected and analysed as part of a year-long research project in 2009 which investigated netbook usage by four, Year Seven Classrooms (11-13 year old students) in an Australian Primary School. It addresses one of the specific research questions from the broader project; namely, “In what ways did varying the ratio of netbook availability – from 1:1 to 1:2 or varying the pattern of availability - 5 days per week for 6 weeks versus 3 days per week for 10 weeks affect student usage in terms of quantum (as a ratio of available time) and modes of use?”

1:1 computing is defined here as the availability of a mobile, wireless enabled device for each student (Liang et al., 2005) whilst 1:2 computing indicates the availability of a mobile, wireless enabled device for every two students. These definitions of 1:1 or 1:2 computing refer only to the level of access and say nothing about actual usage in relation to educational practices (Bebell & O'Dwyer, 2010). Acer Aspire One Netbooks were the mobile, wireless enabled devices used in this project. As the netbooks were similar to the classroom /laboratory computers already in use in terms of software, it was not considered necessary that the students and teachers receive specific training. Findings from the overall research project, related to this article suggest that: i) the netbooks provided in a 1:2 pattern were used up to 30% more than those provided in a 1:1 pattern; and ii) the use of netbooks affected student learning, classroom collaboration, and teaching style and that these changes were more profound in the two classrooms with 1:2 access.

Brief background from the literature

Findings from research conducted in 1:1 laptop computing environments suggest that 1:1 computing leads to changes to pedagogy: e.g. more student centred approaches (Donovan, Hartley, & Strudler, 2007; Swan, Hooft, Kratcoski, & Unger, 2005; Zucker & Hug, 2008); flexible and constructivist teaching styles (Mouza, 2008; Rockman, 2003; Zucker, 2004); and delivery of learning episodes which are more project oriented and inquiry based (Swan, Hooft, Kratcoski, & Schenker, 2007). In regards to student learning, research has documented increased media literacy (Hill & Reeves, 2002; Rockman, 2003), improved writing (Gulek & Demirtas, 2005; Mouza, 2008; Ricci, 1999; Russell, Bebell, & Higgins, 2004), and, in some cases, increased scores on standardized tests (Gulek & Demirtas, 2005; Stevenson, 1998; Suhr, Hernandez, Grimes, & Warschauer, 2010).

However, perspectives contrary to those noted above are also evident in the literature. Lei and Zhao, (2008) report concerns over the effectiveness of the high cost of 1:1 computing programs and note increasing resistance by some parents, school administrators, and educational bureaucracies to their implementation. Selwyn, Potter, & Cranmer (2009) report on usage of ICT by students in British schools and note that “Whilst our data depict a generation of young people for whom ICTs are part of their everyday lives, closer inspection shows many primary pupils’ actual engagement with ICT to be often perfunctory and unspectacular—especially within the school setting” (p. 928). Notwithstanding the findings of Lei and Zhao and Selwyn et al., the broad spectrum of research indicates that 1:1 computing has positive outcomes for students across a range of domains.

In addition to the educational advantages of 1:1 and 1:2 computing, it is incumbent on educational institutions that allocated funds are expended wisely. Budgetary realities often mean that schools struggle with the dilemma of providing cost effective computing without compromising educationally appropriate access to such technology. What is apparent is that research studies completed to date have yet to test specifically the links between hypothesised

outcomes for 1:1 initiatives (Penuel, Tatar, & Roschelle, 2004) and the impact of different implementation strategies to achieve these outcomes (Zucker, 2004). This article reports on a study which utilised mobile computing with four distinct variations in implementation and suggests that the positive outcomes of 1:1 computing noted above can be achieved at less than a 1:1 ratio

Conceptual Framework

Classrooms can be conceived of as sites in which learning occurs as a social and cultural endeavour. Activity Theory, a specific socio-cultural theory, is used as a framework to analyse, synthesise, and evaluate the classroom environments in this research. Activity Theory is considered particularly useful in understanding the range of complex factors related to computer use and how this use affects student learning. Engeström's (1987) conceptualisation of Activity Systems (Figure 1) is used in this research. Engeström suggests that socio-cultural sites can be examined using six key elements. In the system the subject uses tools to attain a specific object in a community context with specific rules and roles of responsibility. Contradictions and tensions between these various elements are resolved to attain a specific outcome. Three particular features of any Activity System approach render it appropriate for this research: i) each classroom is taken as a unit of analysis, providing context and meaning to a range of events; ii) the classroom components can be understood as historical entities; and iii) inner contradictions within the classrooms are analysed as sources of disruption, innovation, change and development (Young, 2005).

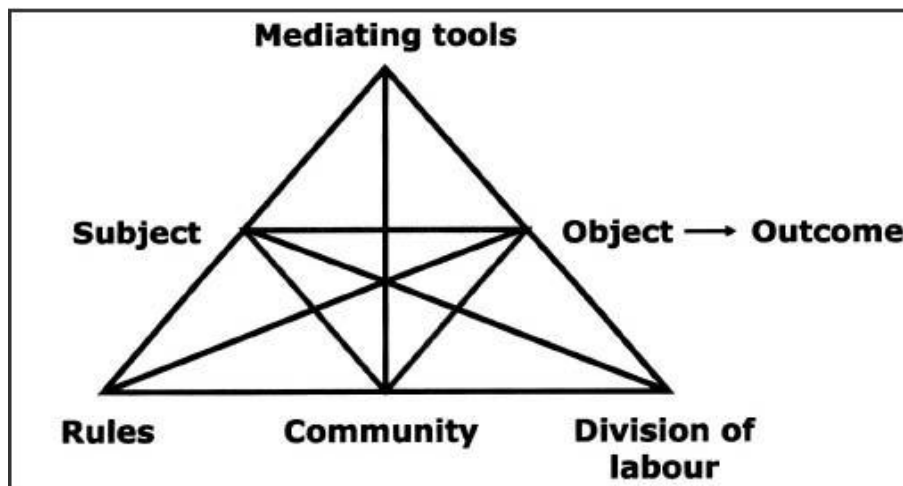


Figure 1 – Activity Systems (Engeström, 1987)

[Insert Figure One Here]

Activity Theory is thus useful in understanding the range of complex historical and socio-cultural factors related to computer use in the four different classrooms in this research and how this usage impacted upon student learning. For instance, a common task for the students in this research was the production of a report. The use of the computer transforms the completed report (through the availability of digital images and text manipulation) but at the same time the historical structure of the report genre limits the potential of the computer (for instance, the report must be text-based; no multimedia). Activity Theory has been used widely as a conceptual and methodological tool in educational research contexts from the Early Years through to Tertiary Education (see Georgeson, 2006; Latheef & Romeo, 2010; Lloyd & Cronin, 2002; Romeo & Walker, 2002; Sweeney, 2010; Zevenbergen & Lerman, 2007). By way of a brief example, both Latheef & Romeo, (2010) and Sweeney (2010) used Activity Theory to examine the impact of Interactive Whiteboards (IWBs) on classroom environments.

Methodology

It is suggested above that classroom environments are complex, historic entities with inherent

contradictions and tensions which, if resolved, result in the growth and development of these environments. Given this, an approach to enquiry was required which captured both the subjective qualities that comprise individual consciousness, interest and motivations as well as the contributions of the physical and social world (Creswell, Shope, Clark, & Green, 2006; Maxwell, 2004). Consequently, a ‘mixed methods’ research approach (Burke & Onwuegbuzie, 2004) was used to direct the investigation of netbook usage by the teachers and students in this study.

As this research sought to determine whether varying the ratio and access pattern to the netbooks affected their use; four different levels of netbook access were provided to four Year 7 classes. In order to determine the impact of different patterns of netbook usage, the netbooks were distributed as per Table 1.

Table 1: Pattern of Netbook Allocation

	Class A (1:1 - 5 days per week)	Class B (1:2 - 3 days per week)	Class C (1:2 - 5 days per week)	Class D (1:1 - 3 days per week)
Number of Netbooks	32	16	16	32
Days per week	5	3	5	3
Number of weeks	6	10	6	10
School Terms	Term 1	Term 2	Term 2	Term 3
Teacher Pseudonym	Vernon	Wendy	Neville	Jasmine

[Insert Table One here]

A range of data collection methods or tools were used to collect data for this article.

- Classroom Observations – (Prior to, during, and after netbook use)
- Semi – structured interviews, student forums, and surveys (Freebody, 2003)
- Data Logging Software installed on the netbooks

Classroom Observations

Classroom observations occurred prior to and during periods of netbook usage.

Approximately 80 observations were conducted across the four classrooms in the study. Each period of observation lasted between 15 – 30 minutes. In order to gain an accurate picture of netbook usage, these observation periods were conducted at random times during the school day and the teachers were not told when these observations would occur. To aid in the data collection of computer usage information a modified version of the *Survey of Computer Use (SCU) Instrument* (Dawson, Cavanaugh, & Ritzhaupt, 2008/2009) was used. This instrument is specifically designed to conduct classroom observations in relation to computer usage.

Further classroom observation data were collected via observation records in the researcher diary and records were kept which detail any direct interactions with students and teachers during these observation periods. Over the course of the project, six, one week long periods of leave were taken by the researcher so that substantial amounts of time could be spent observing the classroom use of the netbooks. The purposes of the classroom observations were two-fold. Firstly, observing the classrooms prior to and during the netbook usage periods generated a range of data about the impact of the netbooks on computer usage in these classrooms and meant that comparisons could be made regarding, for instance, student to student communication via ICTs in the classrooms pre-and-post intervention. Secondly, the observations were triangulated with quantitative data collected via data collected directly from the netbooks.

Semi-structured Interviews and Surveys

The interviews consisted of a mixture of pre-determined questions regarding specific aspects of the project such as the impact of netbooks on specific curriculum areas or the effects of

netbook use on access to information, as well as questions which arose from the nature of the discussion. The semi-structured nature of the interviews thus allowed for deeper probing of participant responses, as the need arose, and also allowed the participants the opportunity to contribute additional reflections, comments or opinions and to ask me questions about the project if they so desired. The initial, interim, and final interviews also contained a set of specific questions related to the classroom environment and curriculum use of the netbooks which required a Likert scale answer. Each of the teachers was interviewed four times - prior to their class using the netbooks, during their use, at the immediate conclusion of their use and then again a period of time (between four to six weeks) later (12 interviews in total). The student interviews were conducted as paired interviews (36 interviews in total). Each pair was interviewed three times - prior to their class using the netbooks, during their use, and at the conclusion of their use. The six students from each class also participated in a discussion forum, conducted approximately 6 weeks after the completion of their netbook usage period. Post-usage information about the classroom environment and patterns of post-netbook computer usage was gathered. The interviews were recorded (with the consent of the participants) and interview notes taken. The interviews were transcribed as soon as possible after the interviews and the transcripts were shown to the participants to ensure the accuracy of the transcription.

Towards the end of the first 6 week period of access it was apparent that qualitative data was only being collected from six students (and their teacher) and that it would be beneficial to collect further qualitative data from all of the students. This data would serve both as a means of verifying what the randomly selected interviewees were reporting, and also as a tool to ensure significant 'student voice'. Consequently, a survey to be completed by all students in the study, was created. The survey questions largely replicated the questions which had been used throughout the student interviews. The data collected from these surveys was

triangulated with interview data, observations, and the qualitative data collected throughout the project to construct a picture of the four classrooms. The responses to the survey regarding the use of the netbooks supported and re-enforced the perspectives that were offered by the interviewed students.

Data Logging Software

Although anecdotal information on computer usage, in terms of both duration and purposes of use, was gathered via observations, interviews, and student forums, actual usage data was also collected directly from the netbooks. Computer data, collected electronically from each netbook, was vital in accurately determining how usage varied according to the different modes of access. Automated data collection is a more reliable method of collecting usage data rather than relying on self-reports of usage. Two tools were used to collect usage data. The primary data tool was a logon script on each netbook which automatically recorded start-up, logon, logoff, and shutdown events. The second technical data tool was Spy KeyLogger, a piece of software which collected information on every keystroke; thus providing information regarding software usage and Internet activity. As part of the ethical clearance for this research, all participants were informed in writing that keystroke data would be collected. Spy KeyLogger also functioned as a pro-active research tool in that it provided entry points into the experiences of the students, as well as allowing triangulation of the data collected from the logon script, classroom observations, interviews and surveys.

Data Analysis

Rather than leaving any analysis until the conclusion of the data collection phase of the project, initial data analysis commenced soon after the start of the project. This early analysis shaped subsequent data collection procedures. Initial analysis involved transcribing interview

data and the processing of classroom observations and other artefacts (Garthwait & Weller, 2005). The data collected were coded into emerging categories of interest, initially based on the six Activity Theory nodes (Subject, Object, Tool, Community, Rules, and Division of Labour). This early analysis primarily related to the data collected from Class A. At later stages throughout the research, as other teachers and classes became involved and other themes arose, these initial transcripts were revisited and, if necessary, this early data was recoded into the emerging themes using NVivo. NVivo has been used as a data analysis tool in a range of ICT related educational projects (see Dunleavy, Dexter, & Heinecke, 2007; Thompson, 2005).

In this project, the terms credibility and transferability are used as guiding concepts in determining the integrity of this research. Credibility and transferability are reflected in the authentic representation, to the reader of the research, of the how the data were collected and the type of analysis that was conducted. Transferability is not concerned with the question of whether the findings are valid for all other contexts, but rather with the question of whether the research findings and analysis are helpful in understanding the reader's context (Bogdan & Biklen, 2007). Credibility is viewed as the fit between what is recorded and presented as data and what actually occurred in the setting under study. Transferability and credibility were enhanced via the employment of a number of strategies recommended by Creswell (1998). These strategies included triangulation of the data; an appropriate length of time spent observing and interviewing; the clarifying and declaring of personal bias; and entering the research site as a participant rather than an observer. Member checking (Eisenhart & De Haan, 2005) was also a research strategy, whereby, after completing data analysis, the researcher returned to the students and teachers in the research and asked them "Is this right?" Where necessary, conclusions were reconsidered to accommodate the follow up

information provided by the participants.

Findings and Discussion

It is the situation in many schools that, due to financial constraints, laptop computers, where available, are shared between two or more classrooms resulting in either a full time 1:2 access ratio, or a 1:1 ratio for 2 or 3 days per week. This research replicated these contexts by varying the ratio of netbook availability – from 1:1 or 1:2 and varying the pattern of availability – (5 days per week versus 3 days per week). For ease of discussion Class A access (1:1 – 5 days per week) will be referred to as FA-FT (full access full time); Class B access (1:2 – 3 days per week) will be referred to as PA-PT (part access part time); Class C access (1:2 – 5 days per week) will be referred to as PA-FT (part access full time); and Class D access (1:1 – 3 days per week) will be referred to as FA-PT (full access part time). Over the course of the school year there were three distinct periods of usage for the class set of netbooks. In Term One, Class A (FA-FT) had access to all of the netbooks for 5 days per week. In Term Two, Classes B (PA-PT) and C (PA-FT) shared the netbooks using 16 netbooks each.. In Term Three, Class D (FA-PT) used all of the netbooks for 3 days per week. As noted earlier, each class had access to the netbooks for a total of 30 school days. Netbook usage, in terms of time, is represented in Figure 2.

Table 2: Average Daily Netbook Usage per Access Period

Access Period	Term 1 (Class A)	Term 2 (Class B & C)	Term 3 (Class D)
Average Daily Use	31 Hours	41 Hours	28 Hours

[Insert Table Two Here]

The information presented in Table 2 illustrates that the set of 32 netbooks, shared between

two classrooms was used, on average, for 10 hours more per day than Class A (FA-FT) and 13 hours more per day than Class D (FA-PT). This suggests that from a quantum of usage perspective, the devices were used for up to 30% longer in the classrooms which shared the devices than in either of the classrooms which had access to the whole set. Based on this information it is suggested that schools get increased return on their investment in the provision of computers in a ratio of 1:2. Whilst overall use of the netbooks was relatively low (average daily use of 58 minutes), classroom usage varied markedly on a day by day basis. For example, although Class A (FA-FT) used the netbooks for an average 54 minutes per day, on some days netbook usage was over 3 hours yet on other occasions they were either not used or used for only 15 minutes per day. Figure 2 presents data regarding usage and patterns of access and is expressed in terms of maximum, minimum and mean usage for each class. In considering the data in Figure 2 it is useful to recall the conditions of use. Each teacher had a total of 30 days netbooks usage. Class A (FA-FT) and C (PA-FT) had 32 and 16 netbooks respectively and had 6 weeks access, 5 days per week. Class D (FA-PT) and B (PA-PT) had 32 and 16 netbooks respectively and had 3 days per week access over ten weeks. The teachers could choose which 3 days per week they used the devices – e.g. Monday, Tuesday, Thursday in Week One, Tuesday, Thursday, Friday in Week Two etc.

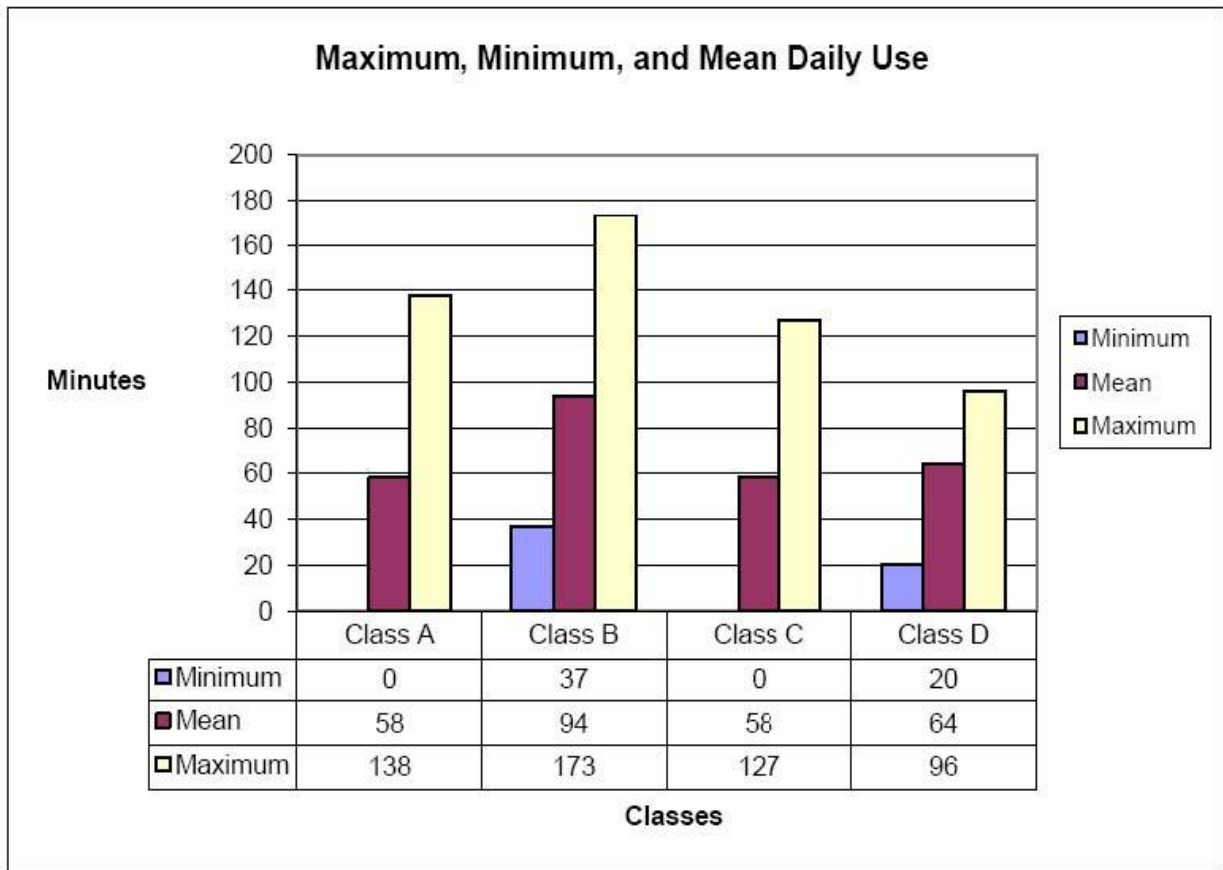


Figure 2 – Maximum, Minimum and Mean Daily Usage per Class

[Insert Figure 2 Here]

Although a large range of usage was evident across all four classes, the classes with three days per week access [Class B (PA-PT) and Class D (FA-PT)], were most consistent in their usage. Figure 2 illustrates that there were no days in which the netbooks were not used. This is in stark contrast with Class A (FA-FT) and Class C (PA-FT), which both recorded a number of days where the netbooks were available but not used. It is apparent that Classes B (PA-PT) and D (FA-PT) were able to avoid external interruptions to classroom teaching time as they could plan which three days each week they would use the netbooks. For instance, they could check the school calendar and establish when external class events were held and then elect not to use the netbooks on those days. This was not an option in this research for the two classes with 5 days a week access.

Data presented thus far indicate that the average use of the netbooks was approximately 60 minutes per day for three classes and just over 90 minutes per day for a fourth class. Over the course of the 30 days, usage fluctuated. On some days, the netbooks were not used and on other days they were used significantly. The findings presented in Figure 2 indicates that the netbooks were used for different amount of times by the four classrooms and that the manner in which this time was utilised also varied. This data, of course, needs to be tempered with considerations of homogeneity between the teachers, classes and prevalence of interruptions due to testing etc. The teachers in this study were all experienced Year 7 teachers with relatively similar ICT skills. The students were allocated to classrooms as per the usual school procedures to achieve, where possible, an even spread across gender, academic ability and behavioural concerns. Major disruptive periods (e.g. National Standardised Tests) were not conducted during netbook access. Taking into account the provisos noted, the data indicates that, from a pure ‘time usage’ formula, the supply of computers in a 1:2 pattern, particularly when this access is provided for three days per week, resulted in the maximum usage. Whilst usage data is relevant in economic terms, it is not the decisive factor in recommending the use of computers in a 1:2 pattern. The educational benefits of 1:2 computing are also considerable and are discussed in the following section.

Availability affects Usage Patterns – an Activity Theory Perspective

In analysing the data, three models of netbook usage were evident. For consistency in referring to these three models, they are referred to as 1:1, 1:2 and 1:1-1/2. Reference to 1:1, indicates that each student in the class used a netbook individually; 1:2 indicates that two students worked in a pair using one netbook; and 1:1-1/2 indicates situations where half the class were using the netbooks on an individual basis whilst the other half of the class was completing a non-netbook activity. By way of example, a non-netbook activity could include a directed teaching episode or a mathematics task where students are completing a worksheet.

In relation to netbook usage, data collected from the devices using Spy KeyLogger indicates that the primary softwares used were Microsoft Office Applications (mainly Word and PowerPoint with some use of Publisher), Internet Explorer and some use of Windows Media Player. Prior to examining in depth the usage of netbooks in the 1:2 classrooms, it is necessary to briefly explore usage in the 1:1 classrooms as this provides a context and a point of contrast to the 1:2 usage. Activity Theory, and in particular, Activity Systems will be used for this exploration. Activity Systems can be used to identify the tensions and contradictions which are evident in classrooms and how the resolution of these tensions can lead to growth. Figure 3 presents the Activity System operating in the two classrooms with 1:1 access. Points of tension and contradiction are indicated by the red arrows. By way of example, the red arrow drawn between Tools and Subject in Figure 3 indicates that the historical use of computers as primarily a tool for productivity (typing of pre-written stories) limited the opportunities for innovation (use of computers for collaboration).

Netbook Usage in the 1:1 Classrooms

In the classrooms with access to 32 netbooks the devices were by and large used as ‘digital textbooks’ whereby the students all use the computers at the same time, for the same task and often from the same, or narrow, range of webpage(s). The teachers decided which activities required the netbooks and usage would only occur for a specified time, to directly support these activities. In both 1:1 classrooms (FA-FT and FA-PT) students used the devices to either produce assignments (narratives, reports) or to complete targeted research (from pre – specified websites) which would be used to write the narrative or report. The students were proficient in performing these project based tasks using the devices. The decision to use the devices in this manner is shaped by the historical factors mentioned previously; that is, computers have historically been used as productivity tools for typing or research, and also by the pattern of access to the computers in these two classrooms.

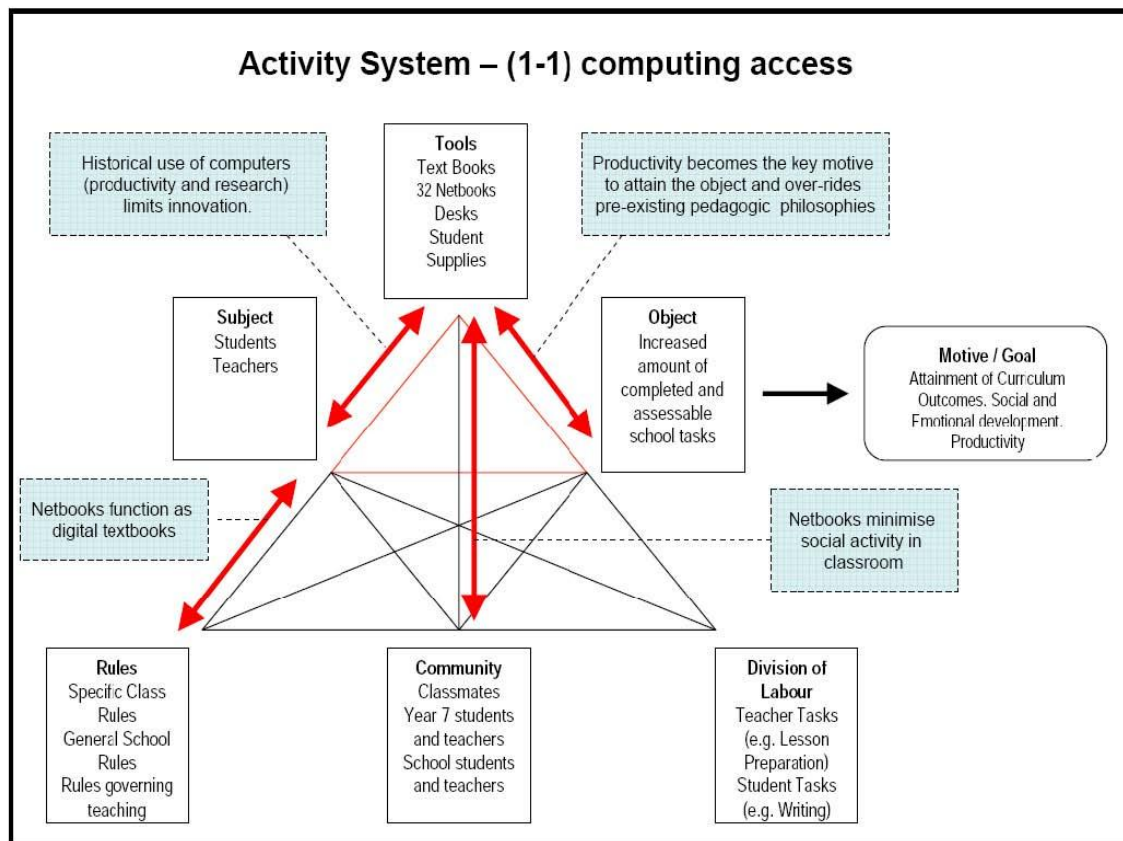


Figure 3 – Activity System illustrating tensions evident in 1:1 classroom

[Insert Figure 3 Here]

The unlimited access to 32 netbooks was a significant determinant of the pattern of use. The unlimited availability of the tool shaped the behaviour of the subject(s). In summarising the attitude of the teachers to 1:1 computing, the thought processes seemed to suggest the following pattern: ‘I have access to enough computers so that each student can use one simultaneously, therefore, regardless as to whether an activity might be better conducted in pairs or in groups, it will be completed individually by the students’. The trajectory of netbook usage in Class D (FA-PT) is a clear example of the substantial influence of the tool on the relationship between the subject and the object.

Despite having access to 32 netbooks, Jasmine initially used the netbooks to support her normal pedagogic practice which is largely based on group activities. The netbooks were

used by the students, at different times during the day, and for specific group rotational tasks. This pattern of usage lasted for just under four weeks. For the last six weeks of her usage, she reverted to the pattern of usage noted in Class A (FA-FT); that is, each student used a netbook individually, at the same time and for the same task, for an hour or so a day. I discussed this change in usage with Jasmine (Teacher, Class D (FA-PT), September 2009) during an interview and her reply was very illustrative of the influence tool availability has on pedagogy:

I have the 32, the kids want to use them and they get a lot done with them, open them up and let's go.

This point was restated in the final interview with Jasmine:

As I said before, if I am given 32 netbooks to use in the future I would use them, but value wise and effects in the classroom wise, I think 16 is the best.
(Jasmine, Teacher, Class D (FA-PT), October 2009)

This pervasive influence of the 32 netbooks was also noticed by Neville and Wendy who each received 16 netbooks. In an interview with Neville the likely impact of 32 netbooks in his classroom was discussed:

I think having access to 32 computers may lead to a deterioration of my teaching as I might spend 5 minutes speaking to the kids in the morning and then getting them to research a project... it would be very tempting to use the 32 as it frees up my time and also the kids are very keen to use them and are productive and on-task when they do so. (Neville, Teacher, Class C (PA-FT), October 2009)

This comment highlights an interesting contradiction as it could be argued that on-task productive and motivated students are highly desirable. What Neville is indicating is that this comes at the potential cost of other forms of desirable educational outcomes such as classroom discussion, collaborative group projects and at some level direct teaching. Whilst all of these are possible in 1:1 environments, pressure was felt from the students and also from an ease of use perspective, to use the devices in the pursuit of individual tasks.

Likewise, in relation to ubiquitous access, Wendy noted:

The students would not have worked together in pairs – I would have felt that I had to use the 32 computers because I would not have wanted to waste them. (Wendy, Teacher, Class B (PA-PT), October 2009)

It appears that for these teachers, the availability of the netbooks meant that activities would be planned where all students could use the netbooks and other activities where no one used the netbooks. Student autonomy in deciding whether or not to use the netbooks was largely non-existent. As a consequence of the pattern of use, social interaction between students during periods of usage was very limited.

Netbook usage in the 1:2 Classrooms

In contrast to the 1:1 classrooms, the presence of the netbooks in the 1:2 classrooms was a major contributory cause of the contradictions which developed in the activity system. The contradictions which were directly related to the 1:2 availability of the netbooks are represented in Figure 4.

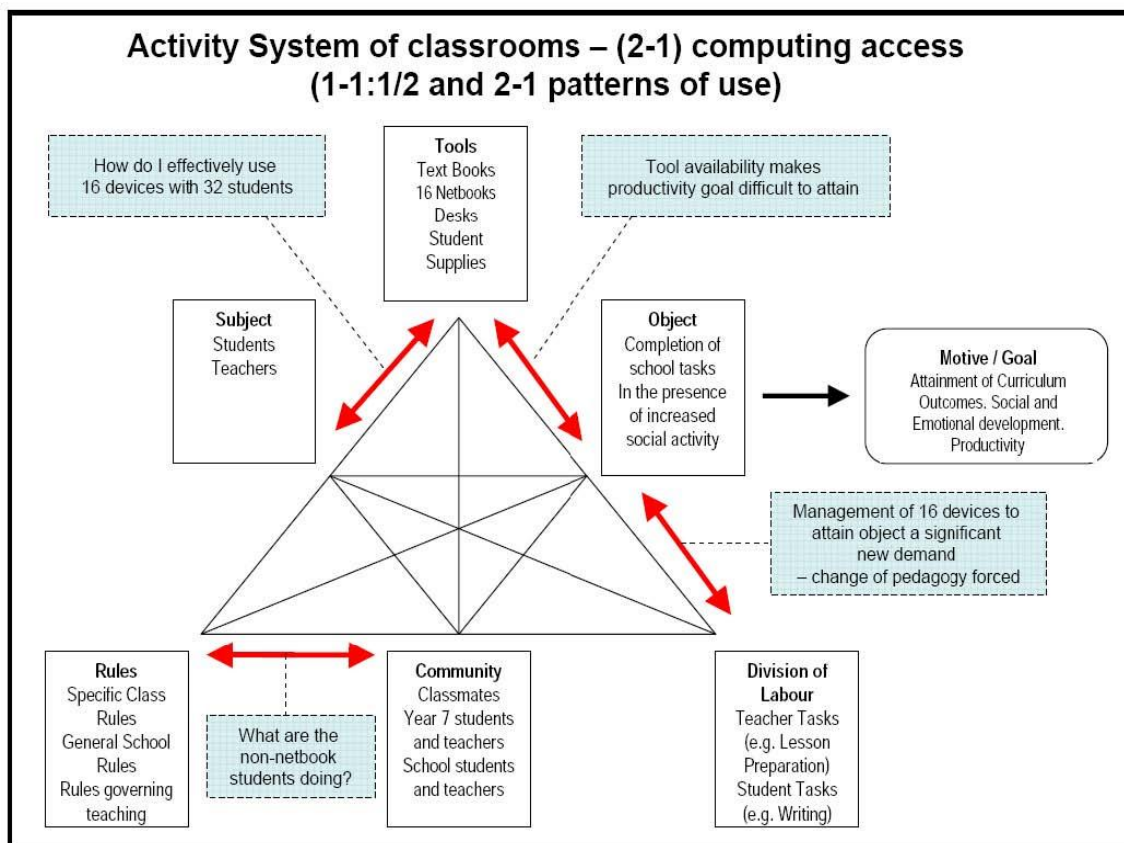


Figure 4– Activity System illustrating tensions evident in 1:1 classroom

[Insert Figure 4 Here]

Prior to discussing the specific contradictions apparent in the 1:2 classrooms (e.g. effective patterns of use for 16 netbooks; modified pedagogic approach) it is necessary to indicate that the 1:2 classrooms also contained many of the contradictions which were evident in the 1:1 classrooms (e.g. productivity vs. social activity). It is also true that the teachers of Class A (FA-FT) and D (FA-PT) were able to more easily reconcile many of the contradictions as they did not force a fundamental change to their pedagogy (see Bateman & Oakley, 2009). Vernon and Jasmine were more able to assimilate the netbooks into pre-existing classroom practices; In Classes B (PA-PT) and C (PA-FT), the limited availability of the tool necessitated a fundamental change to classroom organisation and to the pedagogic practices of these teachers. Both Wendy and Neville were cognisant of this disruption to their teaching:

A critical factor of the 16 computers was that it ‘forced’ me to at least plan two different activities for the students to complete and in the ideal situation ‘forced’ me to teach the 16 students whilst the other 16 students worked on the computers. I am doubtful this would have happened if we had 32 computers. (Neville, Teacher, Class C (PA-FT), June 2009)

Neville identified in this statement that the teaching of 16 students, whilst the other 16 completed a scaffolded task on the computers, was his ‘ideal’ pattern of usage. The limited availability of 16 netbooks meant that Neville (and indeed Wendy) were not as easily able to integrate the technology into the existing classroom pattern as had been the case with Vernon and Jasmine. In these classrooms a clear disruption had been caused which required a modification of pedagogic practice.

New Pedagogical Approach Required

How the teachers in Class B (PA-PT) and Class C (PA-FT) responded to the presence of 16 netbooks, and their pedagogic decisions in response to the device allocation, had significant effects on Teacher Control, Teacher Support, Student Involvement, and Student Affiliation. Both Wendy and Neville used the 16 netbooks in either a 1:2 or in a 1:1-1/2 pattern. For productivity type tasks, for example, typing an assignment or writing a letter to the Principal, the 1:1-1/2 model was deployed with the teacher working with one half of the class whilst the other half worked individually on the netbooks. In the initial stages of a new unit of work, the students would work with a partner on the netbooks in a 1:2 model of usage. In both the 1:2 classrooms, much of the brainstorming prior to the research beginning, and the research phase of the project requiring netbook usage, were completed in pairs. The modified and flexible 1:1-1/2 model of use was considered very successful by both students and teachers. Student comments included:

I like working with partners on the netbooks. I just feel comfortable using them this way. (Paige, Student, Class C (PA-FT), June 2009)

We know each other a little better. We made a lot of friendships with the netbooks because we were with people we did not know. Term Two with the computers helped change how we are with our teacher and with each other. (Kirstene, Student, Class B (PA-PT), May 2009)

Likewise the teachers noted:

I think the partner motivated them.... some kids could lose their motivation without the pairs. (Wendy, Teacher, Class B (PA-PT), June 2009)

I have found with the netbooks that the kids are, within the pair especially, sharing ideas and learning together and talking a bit more and discussing what they are researching. (Neville, Teacher, Class C (PA-FT), April 2009)

The sharing of ideas and collaborative learning mentioned in these comments from the classes with 1:2 access was conspicuously absent in the 1:1 computing scenarios where student comments indicated a preoccupation with individual productivity tasks. The collaboration evident in the 1:2 classrooms during the initial phases of a unit was not evident in the 1:1 classrooms where all components involving the netbooks were completed individually. The limited availability of the netbooks was a catalyst in shifting the learning focus from the teacher, to students working in smaller groups with the teacher, and to scaffolded learning activities utilising the netbooks. In contrast, the 1:1 access in Classrooms

A (FA-FT) and D (PA-FT) promoted a focus on individual, teacher directed activity on the netbooks. In summary, the impact of the computers was felt across all the classrooms and the tensions which were generated in these systems were largely a result of the patterns of access and availability of the netbooks.

Conclusion and Recommendations

A clear conclusion from this project was that the pattern of access not only significantly affected the quantum of netbook usage, but also influenced the manner in which this usage was distributed, which in turn contributed to a range of learning and teaching patterns in these classrooms.

Tool Allocation - a Significant Determinant of Object and Motive

Although the impact of a new tool became influential in the attainment of specific goals in all four classrooms; this impact was felt most noticeably in the classrooms which only had access to 16 computers. This 'limited availability' at best 'facilitated' and, at worst, 'forced' a 1:1-1/2 model of use, whereby students alternated between two types of activities while the netbooks were used. Although this required a greater commitment of the teacher to prepare scaffolded activities for the students to complete on the netbooks (e.g. answering research questions for a later report), and also a willingness to teach the same non-netbook activities twice, this pattern of usage was seen as a positive experience for both students and teachers. Of course, the teachers in the 1:1 model of use could have used the devices in a similar manner. The situation seemed to be that, once the 32 were available, the teachers and students preferred to use them individually in productivity related activities rather than in group or paired situations. It could be the case that if the netbooks were available all year round that this may become less of an issue. Clearly, pedagogic decisions were being made but just as clearly these were influenced in this research by the availability of the devices.

These 1:2 and 1:1-1/2 models of usage had a range of potential advantages and disadvantages for the teachers. The advantages for the teachers were an increase in student engagement and also the opportunity to teach a smaller and more responsive group of students, whilst half of the class were productively engaged in a largely self-managed, netbook activity. The disadvantages were an increased workload for teachers, and also a reduced opportunity to conference with students individually or in small groups as they were more likely to be busy in direct teaching activities with one half of the students. Overall, there are greater benefits in terms of interaction amongst students, and with their teacher in a 1:2 pattern of access than when the students use the netbooks individually in the 1:1 pattern.

Differing Forms of Activity in the Classroom

Classroom activity can be understood in three forms: i) Educational (largely initiated by the teacher); ii) School-going (the completion of teacher set activities by the students); and iii) Social (the social relationships established by students and teachers in curriculum and non-curriculum discourses (Pietsch, 2005). During the periods of their use, the netbooks substantively affected the social activity in three of the classrooms, and in a less significant way in the fourth classroom. Although the level of social activity varied according to the task (e.g. individual reading activities or completion of tests) the level of social activity remained consistently and conspicuously low during all periods of netbook usage in Class A (FA-FT). When the students were using the netbooks, (perhaps as a consequence of only using the netbooks in a 1:1 model), they preferred to work individually and were almost singularly focussed on completing set tasks. This in itself may be considered a positive outcome; however, the completion of set tasks on the netbooks came at the cost of paired and group work which diminished during the netbook usage period. There was no evidence of the

students using the netbooks collaboratively prior to completing the tasks individually. The students preferred, and required, less instruction from the teacher whose role was largely to support individuals in the completion of the task. 1:1 computer access worked against the establishment of high levels of social activity in the classrooms and therefore diminished the opportunities for student collaboration and the shared development of ideas and concepts important for student learning. Although individual task completion is a key student task, the netbooks facilitated this process so effectively that students completed less collaborative work

In contrast, levels of student activity increased markedly in both classrooms with 16 netbooks. The access to 'only' 16 netbooks required a restructuring of student work patterns and resulted in an increase in the amount of paired work. The teachers generally used the 1:2 model for initial brainstorming, research and joint presentations and switched to the 1-1:1/2 usage for the completion of written tasks. The motive of the activity, (paired research or productivity) was critical in determining whether or not a 1:2 or a 1-1:1/2 model was used. Regardless of the pattern of access, the focus of the teachers and students in this project was largely on individual task completion; however, in the 1:2 classrooms the process of achieving an individual completion of the task was more collaborative than in the 1:1 classroom in that parts of the overall task (brainstorming and research) were completed in pairs using the netbook as a tool in this process.

Students noted that they enjoyed paired work on both a social and academic level and that prior to using the netbooks they had not worked very often in pairs. Although these options regarding patterns of use were available to the four teachers, it was only the two teachers who had 16 netbooks who deviated away from a strict 1:1 regime of use. Whilst the pedagogic

approach is a key consideration, patterns of access seemed to be a substantial indicator as to how the devices would be used. A key finding from this research was that, whilst three of the four teachers thought that 16 netbooks were, from both a pedagogic and economic perspective, the best model of use, all of the teachers, given the choice, would opt for the use of 32 netbooks. It appears from the reaction of these teachers that limiting teachers to 16 netbooks directed their pedagogy to a more balanced approach between educational, school going and social activity.

Contributions for School Based Practice

Based on the findings of this research study it is recommended for this particular educational context that netbooks be made available in the ratio of 1:2. The 1:2 provision of netbooks was sufficient to provide a 'critical mass' of computers which resulted in significant use by teachers and students (Norris, Terry Sullivan, Poirot, & Soloway, 2003). Furthermore, the 1:2 pattern of usage had substantial pedagogical advantages over the 1:1 model and appeared to afford the best balance between individual student productivity, student collaboration, direct teacher instruction, and flexibility to respond to other curriculum and extra-curriculum events. It was also the pattern of access which resulted in the greatest use of the devices, in terms of quantum of usage, with the netbooks used 30% more in the 1:2 model than in 1:1 model. As indicated earlier in this article, the increased usage is per device rather than per student. Although extensive data was collected in relation to actual time of use (via the Logon / Logoff script and Key SpyLogger) it was not feasible, from a technical point of view to accurately track individual student usage in a paired context. To do so would require the students to either log on and log off each time either of them used the device or to keep a paper based log of the respective contributions of each student. I suggest that these options are inconvenient and also contrary to the spirit of collaboration in a paired situation. What was clearly evident from classroom observation,

from survey data, and from student and teacher interviews, is that during the collaboration rich activities (brainstorming, initial research, planning of writing activities) the students in the 1:2 classrooms worked in pairs to complete this task. In these situations, student use per device was increased as the whole class were working on 16 computers. Once the students were required to produce individual work (based on their shared research) per student usage in the 1:2 mirrored that in the 1:1 classrooms.

In addition, without compromising the educational advantages of the netbooks to the students and teachers, there are significant economic benefits to schools in the decision to deploy netbooks in the 1:2 model. In the case of the research school, the difference in purchasing one netbook for each student, as opposed to one between two, is in the order of \$300 000. In recommending the 1:2 model, a deliberate attempt to inform and shape a particular pedagogical approach to netbook usage is made. Based on the experiences gleaned from this project, supplying teachers with 32 netbooks encouraged one pattern of usage; namely each student worked individually on the tasks set by the teachers. The teachers were strongly influenced by the 1:1 availability and seemed compelled to use all of the computers at the same time. Whilst this pattern of usage had advantages in terms of productivity, and also in terms of allowing teachers to spend time conferencing with students, it had a negative impact on the level of social activity in the classroom, made it more difficult to promote individual and self-directed learning, and was less viable from an economic point of view with the netbooks unused for large periods of the school week.

In contrast, the classrooms which used the 16 netbooks were characterised by increased levels of student involvement, teacher support and social activity. The students valued highly both the opportunity to work with a peer with the netbooks, and also the opportunity to work individually on the devices as the activity demanded. In addition, and of significant value to

the students, were the increased opportunities to interact with their teacher, at a lower student teacher ratio, which the 1:1-1/2 model encouraged. Further research into the effects of 1:2 access in a range of schools is necessary as a potential alternative to the current 1:1 orthodoxy.

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